Multimaterial glass-ceramic core optical fibers through Powder-in-Tube process

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Since several years, optical fibers attract more and more attention in the materials science community thanks to the rising development of optical fibers with glass-ceramic core [1-3]. Some laser effects have been reported in the literature, among which we can relate the work ofB.N. Samson*et al*, who demonstrated the laser emission of an Nd^{3+}doped fluoride optical fiber around 1055 nm [3]. Those original systems combine the advantages of monocrystals used in solid state lasers and avoid the drawbacks of vitreous core optical fibers usually found in optical fiber laser systems. Indeed, the introduction of crystals in the core of an optical fiber by means of glass-ceramic confers a crystalline environment to the luminescent ions used as doping elements. The low phonon energy of those crystals associated to the high solubility of luminescent ions in crystalline media significantly increases the spectroscopic efficiency of the system and allows new radiative transitions, especially in the visible spectral range. Moreover, the fiber geometry has numerous intrinsic advantages such as good thermal dissipation, high beam quality and a simple all embedded monolithic design which is almost insensitive to dusts and vibrations compared to monocrystalline lasers. However, the fabrication of optical fiber with such original compositionsis difficult if not impossible through classic processes such as MCVD or Rod-in-Tube. The Powder-in-Tube process consists in drawing down to fiber (with a diameter of few hundred of micrometers) a glass tube filled with powdered raw materials. Thus numerous material compositions can be used, provided that it can be elaborated and its thermomechanical properties are not incompatible with those of the material of the cladding [4]. In this current work, we present experimental results about the fabrication of glass-ceramic-core optical fibers by the Powder-in-Tube process. The glass-ceramic we used, which derives from the system SiO_2-Na_2O-ZnO-Ga_2O_3 [5], can contain up to 50_{wt}% of crystals and can be efficiently doped with transition metals. Moreover the size of its nanostructure can be tailored depending onthe SiO_2concentration, making this matrix a material of choice for the development of active glass-ceramic optical fibers [6]. Quantitative SEM-EDS measurements illustrated an evolution of the fiber core composition (compared to the starting bulk material) induced by the diffusion of SiO_2 from the fiber cladding, and TEM imagery demonstrated the formation ofnanocrystals in the fiber core. Later this glass-ceramic will be doped with Cr^{3+} and Ni^{2+} ions in order to generate luminescence emissions in the ranges 690 – 710 nm [6] and 1100 – 1500 nm [7].

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